



(19) Europäisches Patentamt  
European Patent Office  
Office européen des brevets



(11) EP 0 801 096 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:  
15.10.1997 Bulletin 1997/42

(51) Int Cl. 6: C08J 5/18, B32B 27/08,  
B65D 65/40  
// C08L23:08

(21) Application number: 97302480.5

(22) Date of filing: 11.04.1997

(84) Designated Contracting States:  
AT BE CH DE DK ES FI FR GB GR IE IT LI LU NL  
PT SE

• Mudar, Kimberley Ann  
Greer, SC 29651 (US)

(30) Priority: 12.04.1996 US 631489

(74) Representative: Jones, Helen Marjorie Meredith  
Gill Jennings & Every,  
Broadgate House,  
7 Eldon Street  
London EC2M 7LH (GB)

(71) Applicant: W.R. Grace & Co.-Conn.  
New York, New York 10004 (US)

(72) Inventors:

• Lambert, Scott W.  
Simpsonville, SC 29681 (US)

(54) Heat sealable film

(57) A film includes at least one layer comprising a blend of a first polymer having a crystalline melting point of at least 260°F, and a density of at least 0.925 grams per cubic centimeter, and a second olefinic polymer comprising an ethylene/alpha-olefin copolymer with a density of less than 0.916 grams per cubic centimeter, wherein the film heat seals at a temperature of at least 180°F. The film can include a core layer including an oxygen barrier; and two outer layers each including a blend of a first polymer having a crystalline melting point

of at least 260°F, and a density of at least 0.925 grams per cubic centimeter, and a second olefinic polymer comprising an ethylene/alpha-olefin copolymer with a density of less than 0.916 grams per cubic centimeter, wherein the film heat seals at a temperature of at least 180°F. The film can also include one or more intermediate layers disposed between the core layer and respective outer layers, and one or more adhesive layers disposed between respective intermediate and outer layers. Good heat sealability is obtained.

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**Description****FIELD OF THE INVENTION**

5 The present invention relates to a heat sealable film which may be utilized to package a variety of items.

**BACKGROUND OF THE INVENTION**

10 The present invention is directed to a new and useful film. Films, and especially heat shrinkable films are well known for many packaging applications.

An example is BDF-2050 film supplied commercially by W.R. Grace. This film has proven to be very useful in packaging applications where high shrink, good optics, oxygen barrier and other desirable features of the packaging film are needed. Film of this type is disclosed e.g. in U.S. Patent No. 5,004,647 to Shah, incorporated herein by reference in its entirety.

15 Another example is a film, LID 1050, useful in lidding applications. Film of this type is disclosed e.g. in EP 0692374, incorporated herein by reference in its entirety.

It would be desirable to use films, especially heat shrinkable materials like BDF-2050 in end use applications requiring very good heat sealability. For example, in uses where a foamed polystyrene tray is loaded with a food product and then overwrapped, impulse sealing is often used. Equipment such as Ilapak, Ossid, and Rose Forgrave systems 20 are used in such applications. Some of these systems are high speed, producing packages at speeds of up to 100 ppm (parts or packages per minute). This use requires a film with good heat sealing properties, especially hot tack strength. Since hot tack strength is related to the flowability of the film material under heat and pressure, and in particular the flowability of the sealant layer of the film, it is important that the film flow and fuse together quickly under sealing conditions so that reliable heat seals can be made consistently at relatively high speeds.

25 For lidding on foam trays, toughness as measured by a low percentage of abuse failures (cuts) is required. For uses where a polyester or aluminum coated tray is loaded with a food product and then overwrapped with a film, cuts in the tray edges can occur during packaging and distribution. Impulse sealing is used for this type of overwrapping also. Thus, in this end-use application, a combination of good sealing and toughness is needed.

**30 SUMMARY OF THE INVENTION**

In one aspect, the present invention comprises a film comprising at least one layer comprising a blend of a first polymer having acrystalline melting point of at least 127°C (260°F) and a density of at least 0.925 grams per cubic centimeter, and a second olefinic polymer comprising an ethylene/alpha-olefin copolymer with a density of less than 35 0.916 grams per cubic centimeter, wherein the film heat seals at a temperature of at least 82°C (180°F).

In a second aspect, a multilayer film comprises a core layer comprising an oxygen barrier; and two outer layers each comprising a blend of a first polymer having a crystalline melting point of at least 127°C (260°F) and a density of at least 0.925 grams per cubic centimeter, and a second olefinic polymer comprising an ethylene/alphaolefin copolymer with a desnity of less than 0.916 grams per cubic centimeter, wherein the film heat seals at a temperature of at 40 least 82°C (180°F).

In a third aspect, a multilayer film comprises a core layer comprising an oxygen barrier; two intermediate layers each comprising a polyamide; and two outer layers each comprising a blend of a first polymer having a crystalline melting point of at least 127°C (260°F) and a density of at least 0.925 frams per cubic centimeter, and a second olefinic polymer comprising an ethylene/alpha-olefin copolymer with a density of less than 0.916 frams per cubic centimeter, wherein the film heat seals at a temperature of at least 82°C (180°F).

**DEFINITIONS**

The term "core layer" as used herein refers to a centralmost layer of a multi-layer film.

50 The term "outer layer" as used herein refers to what is typically an outermost, usually surface layer of a multi-layer film, although additional layers and/or films can be adhered to it.

The term "intermediate" as used herein refers to a layer of a multi-layer film which is between an outer layer and core layer of the film.

As used herein, the phrase "ethylene/alpha-olefin copolymer" (EAO) refers to such heterogeneous materials as 55 linear medium density polyethylene (LMDPE), linear low density polyethylene (LLDPE), and very low and ultra low density polyethylene (VLDPE and ULDPE); as well as homogeneous polymers (HEAO) such as TAFMER (TM) ethylene/alpha olefin copolymers supplied by Mitsui Petrochemical Corporation and metallocene-catalyzed polymers such as EXACT (TM) materials supplied by Exxon. These materials generally include copolymers of ethylene with one or

more comonomers selected from  $C_4$  to  $C_{10}$  alpha-olefins such as butene-1 (i.e., 1-butene), hexene-1, octene-1, etc. in which the molecules of the copolymers comprise long chains with relatively few side chain branches or cross-linked structures. This molecular structure is to be contrasted with conventional low or medium density polyethylenes which are more highly branched than their respective counterparts. Other ethylene/alpha-olefin copolymers, such as the long chain branched homogeneous ethylene/alpha-olefin copolymers available from the Dow Chemical Company, known as AFFINITY (TM) resins, are also included as another type of ethylene/alpha-olefin copolymer useful in the present invention.

"High density polyethylene" (HDPE), as defined herein, has a density of 0.94 grams per cubic centimeter or more, "linear medium density polyethylene" (LMDPE) as used herein, has a density from 0.925 grams per cubic centimeter to 0.939 grams per cubic centimeter, "linear low density polyethylene" (LLDPE) as used herein has a density in the range of from about 0.916 to 0.924 grams per cubic centimeter, and "very low density polyethylene" has a density of less than 0.916 grams per cubic centimeter.

"Heat shrinkable" is defined herein as a property of a material which, when heated to an appropriate temperature above room temperature (for example 96°C.), will have a free shrink of 5% or greater in at least one linear direction.

Films of the invention will have a free shrink of preferably at least 10% in at least one linear direction at 96°C.

"Polymer" herein includes copolymers, terpolymers, etc. "Copolymer" herein includes bispolymers, terpolymers, etc.

All compositional percentages used herein are calculated on a "by weight" basis.

## 20 BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1 to 6 are schematic cross-sectional views of films of the present invention.

FIG. 7 is a schematic of an overwrapped tray.

## 25 DESCRIPTION OF THE PREFERRED EMBODIMENTS

The film of the present invention can be a monolayer film. It comprises a blend of a first polymer having a crystalline melting point of at least 260°F and a density of at least 0.925 grams per cubic centimeter, and a second olefinic polymer comprising an ethylene/alpha-olefin copolymer with a density of less than 0.916 grams per cubic centimeter, wherein the blend heat seals at a temperature of at least 180°F.

The first polymer is preferably ethylene polymer having a density of at least 0.925 grams per cubic centimeter, polypropylene, and/or propylene/ethylene copolymer. Blends of these materials can be used. The ethylene polymer is preferably an ethylene/alpha-olefin copolymer with a  $C_4$  to  $C_{10}$  comonomer, more preferably linear medium density polyethylene. The core layer can also comprise high density polyethylene. Ethylene polymers with a density of at least 0.926 g/cc, such as 0.927, 0.928, 0.929, and 0.930 are included. Preferred are materials with a density of at least 0.931 g/cc, such as 0.935 g/cc.

The second polymer is preferably ethylene polymer having a density of less than 0.916 grams per cubic centimeter. The ethylene polymer having a density of less than 0.916 grams per cubic centimeter film is preferably an ethylene/alpha-olefin with a  $C_4$  to  $C_{10}$  comonomer, such as very low density polyethylene. Single-site catalyzed polymer, such as metallocene catalyzed polymer, can be used. Preferred densities for the second polymer are less than 0.915 g/cc, such as less than 0.914, 0.913, 0.912, and 0.911 g/cc. Densities of less than 0.910, such as less than 0.905, 0.904, 0.903, 0.902, 0.901, and 0.900 g/cc are included, such as less than 0.890, and 0.880 g/cc.

An optional third polymer which can be used with the first and second polymers comprises ethylene/unsaturated ester, preferably ethylene/vinyl ester copolymer such as ethylene/vinyl acetate copolymer, or ethylene/alkyl acrylate copolymer such as ethylene/butyl acrylate copolymer; or an ethylene polymer having a density of between 0.916 and 0.924 grams per cubic centimeter, such as linear low density polyethylene.

Referring to FIG. 1, which is a cross-sectional view of a preferred two layered embodiment of the present invention, it is seen that this embodiment comprises a core layer 14, and an outer layer 12. Core layer 14 comprises an oxygen barrier polymeric material, such as ethylene/vinyl alcohol copolymer, vinylidene chloride copolymer, polyester, and polyamide.

Outer layer 12 comprises any of the materials described above for the monolayer film.

FIG. 2 describes a three layer embodiment of the present invention, layers 14 and 12 corresponding in composition to those of Figure 1. Outer layer 16, disposed on the opposite side of core layer 14 from layer 12, can comprise any of the materials disclosed for layer 12.

Figure 3 illustrates a film comprising a core layer 24 corresponding in composition to core layer 14 of Figure 2; two layers 22 and 26 corresponding in composition to layers 12 and 16 respectively, and a fourth layer 20. Layer 20 can represent an additional layer, e.g. an abuse resistant or heat sealable layer made from any suitable polymer, such as a polyolefin, polyamide, or polyester; or it can represent a discrete film laminated to layer 22.

Figure 4 shows a film comprising a core layer 34, corresponding to core layer 14 of Figure 2. Two intermediate layers 32 and 36 preferably comprise a polyolefin, anhydride-modified polyolefin, or polyamide. These layers can include polymeric adhesives such as anhydride-grafted polymers, e.g. anhydride-grafted LLDPE; ethylene/alpha olefins such as LLDPE, or even conventional adhesives such as polyurethane. Layers 32 and 36 can also include ethylene/unsaturated ester copolymer, such as ethylene/vinyl ester copolymer, e.g. ethylene/vinyl acetate copolymer, or ethylene/alkyl acrylate copolymer, e.g. ethylene/ethyl acrylate copolymer, ethylene/methyl acrylate copolymer, or ethylene/butyl acrylate copolymer; or ethylene/acid copolymer, such as ethylene/acrylic acid copolymer, or ethylene/methacrylic acid copolymer. Two outer layers 30 and 38 correspond in composition to layers 12 and 16 respectively. Outer layers 30 and 38 are preferably surface layers.

Figure 5 shows a six layer embodiment in which layers 40, 42, 44, 46, and 48 correspond in composition to layers 30, 32, 34, 36, and 38 respectively. Layer 50 corresponds in composition to layer 20.

Figure 6 shows a seven layer embodiment in which layers 60, 62, 64, 66, and 68 correspond in composition to layers 30, 32, 34, 36, and 38 respectively. Intermediate layers 70 and 72 comprise a polymer, more preferably a polyamide, including copolyamides and blends of polyamides.

Figure 7 shows a package 80 wherein a foamed tray 82 contains a food product (not shown). The tray is overwrapped with film 84, and film is sealed at impulse seals 86a and 86b, and typically a bottom seal (not shown).

The invention can be further understood by reference to the examples given below. These films can be made by a conventional cast coextrusion, extrusion coating, extrusion lamination, conventional lamination, or other suitable process. If desired, these films can be partially or totally crosslinked by electronic or chemical means. If desired for a given end use, these films can be oriented by trapped bubble, tenterframe, or other suitable process. They can thereafter optionally be heat shrinkable, and optionally annealed. Final film thicknesses can vary, depending on process, end use application, etc. Typical thicknesses range from 2.5 to 500 $\mu$ m (0.1 to 20 mils), preferably 5 to 250 $\mu$ m (0.2 to 10 mils) such as 7.5 to 150 $\mu$ m (0.3 to 6 mils), 10 to 100 $\mu$ m (0.4 to 4 mils), 12.5 to 75 $\mu$ m (0.5 to 3 mils) such as 12.5 to 50 $\mu$ m (0.5 to 2 mils or 12.5 to 37.5 $\mu$ m (0.5 to 1.5 mils).

Crosslinking by Irradiation can be done by any conventional means. In the irradiation process, the film is subjected to an energetic radiation treatment, such as corona discharge, plasma, flame, ultraviolet, X-ray, gamma ray, beta ray, and high energy electron treatment, which induce cross-linking between molecules of the irradiated material. The irradiation of polymeric films is disclosed in U.S. Patent No. 4,064,296, to Bornstein, et. al., which is hereby incorporated in its entirety, by reference thereto. Bornstein, et. al. disclose the use of ionizing radiation for crosslinking the polymer present in the film. Radiation dosages are referred to herein in terms of the radiation unit "RAD", with one million RADS, also known as a megarad, being designated as "MR", or, in terms of the radiation unit kiloGray (kGy), with 10 kiloGray representing 1 MR, as is known to those of skill in the art. A suitable radiation dosage of high energy electrons is in the range of up to about 10-200 kGy, more preferably about 20-180 kGy, and still more preferably, 30-160 kGy, such as 45 to 75 kGy. Preferably, irradiation is carried out by an electron accelerator and the dosage level is determined by standard dosimetry methods. Other accelerators such as a Vander Graff or resonating transformer may be used. The radiation is not limited to electrons from an accelerator since any ionizing radiation may be used. The ionizing radiation crosslinks the polymers in the film. The more preferred amount of radiation is dependent upon the film and its end use.

Table I identifies the materials used in the examples. The remaining tables describe the structure and properties of films made with these materials. Properties of the films are further explained in the footnotes to Table 1.

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TABLE 1

MATERIAL	TRADENAME	SOURCE
PE1	Dowlex <sup>TM</sup> 2045.04	Dow
PE2	Dowlex 2037	Dow
PE3	Affinity <sup>TM</sup> PF 1140	Dow
PE4	Affinity PL 1270	Dow
PE5	Exact <sup>TM</sup> 4011	Exxon
PE6	Attane <sup>TM</sup> 4202	Dow
PE7	SLP-8-6031	Exxon
PE8	Exact 3027	Exxon
PE9	Affinity PL 1880	Dow
PE10	Affinity FW 1650	Dow

TABLE 1 (continued)

MATERIAL	TRADENAME	SOURCE
PE11	Affinity FM 1570	Dow
PE12	Affinity PL 1840	Dow
PE13	Affinity HF 1030	Dow
EV1	PE 1335	Rexene
AD1	Admer™ SF 700 A	Mitsui
AD2	Bynel™ CXA 4104	DuPont
PP1	PD 9302	Exxon
PP2	Eltex™P KS 409	Solvay
PB1	0300	Shell
PB2	DP 1560	Shell
OB1	E-151	Evalca
PA1	Grilon™CF6S	EMS
PA2	Ultramid™ C-35	BASF

PE1 = LLDPE, an ethylene/ 1-octene copolymer with a density of 0.920 gm/cc and an octene-1 comonomer content of 6.5%.

PE2 = LMDPE, an ethylene/ 1-octene copolymer with a density of 0.935 gm/cc. and an octene-1 comonomer content of 2.5%.

PE3 = single site-catalyzed ethylene/ 1-octene copolymer with a density of 0.8965 gm/cc and octene-1 content of 14% by weight.

PE4 = single site-catalyzed ethylene/ 1-octene copolymer with a density of 0.898 gm/cc and octene-1 content of 13% by weight.

PE5 = single site-catalyzed ethylene/ 1-butene copolymer with a density of 0.885 gm/cc.

PE6 = ethylene/ 1-octene copolymer with a density of 0.912 gm/cc and octene-1 content of 9% by weight.

PE7 = single site-catalyzed ethylene/ 1-hexene copolymer with a density of 0.903 gm/cc.

PE8 = single site-catalyzed ethylene/ 1-butene copolymer with a density of 0.900 gm/cc.

PE9 = single site-catalyzed ethylene/ 1-octene copolymer with a density of 0.902 gm/cc and octene-1 content of 12% by weight.

PE10 = single site-catalyzed ethylene/ 1-octene copolymer with a density of 0.902 gm/cc and octene-1 content of 12% by weight.

PE11 = single site-catalyzed ethylene/ 1-octene copolymer with a density of 0.915 gm/cc and octene-1 content of 7.5% by weight.

PE12 = single site-catalyzed ethylene/ 1-octene copolymer with a density of 0.908 gm/cc and octene-1 content of 9.5% by weight.

PE13 = single site-catalyzed ethylene/ 1-octene copolymer with a density of 0.935 gm/cc and octene-1 content of 2% by weight.

EV1 = ethylene vinyl acetate copolymer with 3.3% vinyl acetate monomer.

AD1 = anhydride-grafted polyolefin blend.

AD2 = anhydride-grafted polyolefin in ethylene-butene copolymer.

PP1 = propylene/ ethylene copolymer (3.3 % ethylene).

PP2 = propylene/ ethylene copolymer (3.2 % ethylene ).

PB1 = polybutylene.

PB2 = polybutylene.

OB1 = ethylene/vinyl alcohol copolymer (44 mole % ethylene ).

PA1 = nylon 6,12 copolymer.

PA2 = nylon 6,66 copolymer.

In Table 2, six five- layer film structures in accordance with the invention, and one control film (C.1) are disclosed. These were each 25 $\mu$ m (1 mil (100 gauge)) thick, and made by a coextrusion of the layers, and each had the structure:

A/B/C/B/A

The thickness ratio of the layers was:

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layer A	layer B	layer C	layer B	layer A
2	2	1	2	2

All the films were biaxially oriented at 3.8 x 3.8 in the machine and transverse directions respectively. All films were irradiated by electron-beam irradiation.

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The A layers of the films were a blend of 50% PE1, 25% PE2, and 25% of one of the materials indicated in Table 1, and identified for each example in Table 2. A small amount of anhydrous aluminum silicate (an antiblock) and mono- and diglyceride/propylene glycol (an antifog) were compounded into the resin blend such that, after compounding, the additives comprised about 6% of the total compounded blend.

The B layers were AD2; The C layer of the films were 90% OB1 + 10% PA1.

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Table 2

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<u>Physical Property</u>	<u>C. 1</u>	<u>Ex. 1</u>	<u>Ex. 2</u>	<u>Ex. 3</u>	<u>Ex. 4</u>	<u>Ex. 5</u>	<u>Ex. 6</u>
third component in "A" layers	EV1	PE8	PE9	PE10	PE11	PE6	PE7
Processability <sup>a</sup>	+	+	+	+	+	+	*
Hot tack window <sup>b</sup> (°C)	115- 155	115- 135	115- 145	115- 145	115- 145	115- 145	120- 155
Peak Force <sup>c</sup> (N)	2.2	1.5	2.0	2.4	2.0	2.1	2.1
static C.O.F.(out/SS) <sup>d</sup>	0.41	0.44	0.43	0.39	0.35	0.36	0.77
Film Melt Flow <sup>e</sup> (g/10 min.)	2.8	3.2	4.0	2.9	4.8	3.6	1.5
Clarity <sup>f</sup>	n/a	+	+	s	s	s	n/a
Haze <sup>g</sup>	n/a	s	s	w	w	w	n/a
Sealing Window <sup>h</sup>	115- 185	100- 185	105- 195	105- 195	105- 170	110- 195	**
Leakers <sup>i</sup> (%) 50 ppm	0	3	0	1	5	0	n/a
Leakers <sup>i</sup> (%) 70 ppm	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Machinability <sup>j</sup> 50 ppm	++	+	+	p	++	+	**

5 ppm = parts (packages) per minute.

n/a = not available or applicable.

10 <sup>a</sup> Processability is a qualitative assessment of the ease of making the film. The scale used here is:

+ = good;

\* = welding occurred during manufacture.

15 <sup>b</sup> Hot tack herein is the force required to separate a heat seal (i.e. separate sealed film plies) of a one inch wide sample. It is measured by sealing the film together for 0.5 seconds with heat and pressure; 20 releasing the heat and pressure; waiting 3 seconds (dwell time); and pulling the sealed film plies apart. Hot tack window is the range of 25 available sealing temperatures within which the film will, when sealed at a temperature within that range, generally have sufficiently high hot tack to make an acceptable package. Sealing temperature is the seal bar 30 temperature setting of the particular equipment on which the film is sealed.

35 <sup>c</sup> Peak Force is the maximum hot tack force at any temperature in the hot tack window.

40 <sup>d</sup> = ASTM D 1894.

<sup>45</sup> <sup>e</sup> = ASTM D 1238 at Condition E (230°C/21.6 kg).

<sup>f</sup> = ASTM D 1003-61.

45 <sup>g</sup> = ASTM D 1003-61. The scale used here for both clarity and haze is:

<sup>50</sup> ++ = much better than C.1;

+ = better than C.1;

s = same as C.1; and

w = worse than C.I.

<sup>b</sup> Sealing Window is the range of available sealing temperatures (°C) within which the film will, when sealed at a temperature within that range, generally have sufficient seal strength to provide an acceptable, hermetically sealed package with less than 5% seal failures. Sealing temperature is the seal bar temperature setting of the particular equipment on which the film is sealed. Values here are for film run on an Ilapak Delta P machine at 50 ppm.

<sup>i</sup> Leakers are packages that leak after they are sealed, usually during storage or distribution, as a result of inadequate seals. They are tested by submerging packages in a pressurized tank filled with water, and checking for escaping air bubbles.

j Machinability is a qualitative assessment of the ease of using and tracking the film on typical packaging equipment. The scale used here is:

**++ = good;**

+ = problematic;

p = poor, and

\*\* = not machinable.

In Table 3, four additional five-layer film structures of the invention, and one control film (C.2) are disclosed. C.2 was compositionally and structurally like C.1. Examples 7 to 10 were coextruded, and each had the same A/B/C/B/A structure, thickness, thickness ratio of each layer, degree of irradiation and orientation as in Examples 1 to 6.

The A layers of the films were a blend of 50% PE2, and 50% of the material identified for each example in Table 3. Slip and antiblock additives comprised about 6% of the total compounded blend.

The B layers of the films were AD2

The C layer of the films was 90% OB1 + 10% PA1.

Table 3

<u>Physical Property</u>	<u>C. 2</u>	<u>Ex. 7</u>	<u>Ex. 8</u>	<u>Ex. 9</u>	<u>Ex. 10</u>
second component in "A" layers	n/a	PE8	PE11	PE6	PE9
Processability <sup>a</sup>	+	+	+	+	*
Hot tack window <sup>b</sup> (°C)	115- 145	none	115- 145	115- 145	115- 135
Peak Force <sup>c</sup> (N)	1.5	0.7	2.1	1.6	1.4

Table 3 (continued)

Physical Property	C. 2	Ex. 7	Ex. 8	Ex. 9	Ex. 10
static C.O.F.(out/SS) <sup>d</sup>	0.32	0.66	0.43	0.74	***
Film Melt Flow <sup>e</sup> (g/10 min.)	1.7	4.1	3.9	2.1	4.2
Clarity <sup>f</sup>	n/a	w	w	w	+
Haze <sup>g</sup>	n/a	+	+	+	++
Sealing Window <sup>h</sup>	80- 165	90- 155	90- 175	80- 155	80- 90
Leakers <sup>i</sup> (%) 50 ppm	0	1	0.5	0.5	--
Leakers (%) 70 ppm	17	79	31	3	--
Machinability <sup>j</sup> 50 ppm	++	p	+	p	**

\*\*\* = blocked.

25 In Table 4, five additional five-layer film structures of the invention, and one control film (C.3) are disclosed. C.3 was compositionally and structurally like C.1. Examples 11 to 15 were coextruded, and each had the same A/B/C/B/A structure, thickness, thickness ratio of each layer, degree of irradiation and orientation as in Examples 1 to 6, except that the film of Ex. 12 was irradiated to a greater degree than the film of Ex. 11.

30 The A layers of the films of Examples 11, 12, and 15 were a blend of 50% PE2, and 50% of the material identified for these examples in Table 4.

The A layers of the film of Example 13 was a blend of 30% PE2, and 70% of PE11.

The A layers of the film of Example 14 was a blend of 30% PE2, 40% PE11, and 30% PE12.

Slip and antiblock additives comprised about 6% of the total compounded blend.

The B layers of the films were AD2.

35 The C layer of the films was 90% OB1 + 10% PA1.

Table 4

Physical Property	C. 3	Ex. 11	Ex. 12	Ex. 13	Ex. 14	Ex. 15
second component in "A" layers	n/a	PE11	PE11	-	-	PE12
Processability <sup>a</sup>	+	+	+	+	+	+
Hot tack window <sup>b</sup> (°C)	115- 145	115- 145	n/a	110- 145	115- 145	115- 145
Peak Force <sup>c</sup> (N)	1.5	2.0	n/a	2.2	1.7	2.0
static C.O.F.(out/SS) <sup>d</sup>	0.37	0.36	n/a	0.39	0.43	0.43
Film Melt Flow <sup>e</sup> (g/10 min.)	2.4	2.7	n/a	3.3	2.3	2.2
Clarity <sup>f</sup>	n/a	+	n/a	+	+	+
Haze <sup>g</sup>	n/a	s	n/a	s	+	w
Sealing Window <sup>h</sup>	110- 180	105- 155	105- 155	105- 200	105- 155	105- 200

Table 4 (continued)

Physical Property	<u>C. 3</u>	<u>Ex. 11</u>	<u>Ex. 12</u>	<u>Ex. 13</u>	<u>Ex. 14</u>	<u>Ex. 15</u>
Leakers <sup>i</sup> (%) 50 ppm	5	4	3	18	2	8
Leakers (%) 70 ppm	n/a	10	78	26	43	15
Machinability <sup>i</sup> 50 ppm	++	++	++	++	p	+

15 In Table 5, seven additional five-layer film structures of the invention, and one control film (C.4) are disclosed. C. 4 was compositionally and structurally like C. 1. Examples 16 to 21 were coextruded, and each had the same A/B/C/B/A structure, thickness, thickness ratio of each layer, degree of irradiation and orientation as in Examples 1 to 6, except that the film of Ex. 18 was irradiated to a lesser extent than the film of Ex. 18a.

16 The A layers of the film of Example 16 were a blend of 50% PE 13, and 50% of PE6.

20 The A layers of the films of Examples 17 to 21 were a blend of 40% PE2, 30% PE11, and 30% of the material identified for these example in Table 4.

25 Slip and antiblock additives comprised about 6% (Example 16) or 4.5% (Examples 17 to 21) of the total compound-blend.

The B layers of the films were AD2.

26 The C layer of the films was 90% OB1 + 10% PA1.

27 Two additional films of the invention, Examples 22 and 23, not described in the Tables, had the same structure as Examples 17 to 21, but with the third component in the "A" layers comprising PB1 (Ex.22) and PB2 (Ex.23).

Table 5

Physical Property	<u>C. 4</u>	<u>Ex. 16</u>	<u>Ex. 17</u>	<u>Ex. 18</u>	<u>Ex. 18a</u>	<u>Ex. 19</u>	<u>Ex. 20</u>	<u>Ex. 21</u>
third component in "A" layers	n/a	n/a	PE3	PE5	PE5	PE4	PP1	PP2
Processability <sup>a</sup>	+	RP	HB	HB	HB	HB	HB	HB
Hot tack window <sup>b</sup> (°C)	115-140	115-145	110-140	115-120	115-120	110-145	110-185	110-185
Peak Force <sup>c</sup> (N)	1.4	1.9	1.7	1.0	1.0	1.8	1.7	2.4
static C.O.F.(out/SS) <sup>d</sup>	0.35	0.38	0.30	0.32	0.32	0.28	0.36	0.34
Film Melt Flow <sup>e</sup> (g/10 min.)	3.3	3.7	2.6	n/a	1.8	3.2	3.8	3.2
Clarity <sup>f</sup>	n/a	+	w	w	w	w	w	w
Haze <sup>g</sup>	n/a	w	w	w	w	w	w	w
Sealing Window <sup>h</sup>	105-165	105-175	105-195	105-175	105-200	100-200	none	none
Leakers <sup>i</sup> (%) 50 ppm	3	5	0	2	1	1	n/a	n/a
Leakers (%)	4	11	31	33	100	42	n/a	n/a

Table 5 (continued)

<u>Physical Property</u>	<u>C. 4</u>	<u>Ex. 16</u>	<u>Ex. 17</u>	<u>Ex. 18</u>	<u>Ex. 18a</u>	<u>Ex. 19</u>	<u>Ex. 20</u>	<u>Ex. 21</u>
70 ppm								
Machinability <sup>j</sup> 50 ppm	++	++	++	++	++	++	++	++
RP = reduced pressure.								
HB = hazy bubble.								

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In Table 6, five additional five-layer film structures of the invention, and one control film (C.5) are disclosed. C.4 was compositionally and structurally like C. 1. Examples 24 to 26a were coextruded, and each had the same A/B/C/B/A structure, thickness, thickness ratio of each layer, and orientation as in Examples 1 to 6. Ex. 25 and 26a were irradiated at the same absorbed dosage; Ex. 25a at a greater dosage than Ex. 25; and the film of Ex. 26 a lesser dosage than Ex. 25.

The A layers of the film of Example 24 were a blend of 50% PE1, 25% PE2, and 25% PE6. The A layers of the film of Examples 25 and 25a were 50% PE2, and 50% PE6. The A layers of the film of Examples 26 and 26a were 40% PE2, and 60% PE6. Antifog and antiblock additives were present in small amounts in these examples.

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The B layers of the films were AD2.

The C layer of the films was 90% OB1 + 10% PA1.

Table 6

<u>Physical Property</u>	<u>C. 5</u>	<u>Ex. 24</u>	<u>Ex. 25</u>	<u>Ex. 25a</u>	<u>Ex. 26</u>	<u>Ex. 26a</u>
Processability <sup>a</sup>	+	+	+	+	+	+
Hot tack window <sup>b</sup> (°C)	115- 140	115- 140	115- 140	115- 135	115- 150	115- 140
Peak Force <sup>c</sup> (N)	1.9	2.5	2.2	2.0	2.3	2.4
Clarity (%)	75	82	75	76	80	80
Haze (%)	6.7	5.7	6.9	6.6	5.8	5.8
Sealing Window <sup>h</sup>	110- 210	110- 210	110- 210	110- 210	110- 180	110- 210
Leakers <sup>i</sup> (%) 50 ppm	1	0	0	1	0	1
Leakers <sup>i</sup> (%) 70 ppm	2	2	2	2	2	20
Film Melt Flow <sup>e</sup>	2.7	4.5	4.1	n/a	n/a	n/a
RP = reduced pressure.						
HB = hazy bubble.						

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Two additional films of the invention, Exs. 27 and 28, and two corresponding control films (C.6 and C.7) were made, each having the structure:

A/B/C/D/C/B/A

C.6 had the structure:

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5                    25% PE1                    90% OB1                    25% PE1  
+ 50% PE2 / PE2 / AD1 /                    +                    / AD1 / PE2 / + 50% PE2  
+ 25% EV1                    10% PA1                    + 25% EV1

Example 27 had the structure:

10                    50%PE2                    90 OB1                    50PE2  
+                    / PE2 / AD1 /                    +                    / AD1 / PE2 / +  
50%PE6                    10 PA1                    50PE2

15                    C.6 and Ex. 27 had layer thickness ratios:

3/1/1/1/1/3

These films were oriented at 3.8 x 3.8 in the machine and transverse directions respectively. Both films were irradiated.

A small amount of antiblock and antifog additives were included in the outside layers of each film.

20                    Performance data comparing Example 27 and Control 6 is found in Table 7.

Table 7

Physical Property	C. 6	Ex.27
Hot tack window <sup>b</sup> (°C)	115- 130	120- 130
Peak Force <sup>c</sup> (N)	1.7	1.6
Film Melt Flow <sup>e</sup> (g/10 min.)	6.3	6.1
Sealing Window <sup>h</sup>	90-170	100-140
Leakers (%) 70 ppm	78	15

C.7 had the structure:

40                    75PE1                    80PA2                    90 OB1                    80PA2                    75PE1  
+                    /AD2/                    +                    / +                    / +                    / AD2 /                    +

45                    25PE2                    20PA1                    10 PA1                    20PA1                    25PE2

C.7 had layer thickness ratios:

3/1/1/1/1/3

50                    Example 28 had the structure:

55                    50PE2                    80PA2                    90 OB1                    80PA2                    50PE2  
+                    /AD2/                    +                    / +                    / +                    /AD2/                    +  
50PE6                    20PA1                    10 PA1                    20PA1                    50PE6

Ex. 28 had layer thickness ratios:

2/2/1/1/1/2/2

Control 7 and Ex. 28 were oriented at 3.4 x 3.4 in the machine and transverse directions respectively. Both films were irradiated. A small amount of antiblock and antifog additives were included in the outside layers of each film.

5 Performance data comparing Example 28 and Control 7 is found in Table 8.

Table 8

Physical Property	C. 7	Ex.28
Hot tack window <sup>b</sup> (°C)	115- 170	115- 170
Peak Force <sup>c</sup> (N)	4.3	5.8
Sealing Window <sup>h</sup>	160-170	130-230
Leakers (%) 50 ppm	7	0
Abuse Failure (%)	11	4

The abuse failure data of Table 8 is further described in Table 9.

Table 9

Example	Corner Cut	Edge Cut	Bottom Abrasion	Total Abuse Failures*
C.7	0	6	2	8 (11%)
28	1	2	0	3 (4%)

\*N = 72. Test was run using Thermaplate SF 66050 CPET Tray.

The film of the present invention can have any suitable number of layers; can be a monolayer film, or have 2,3,4,5,6,7,8,9, or more layers. Films can be symmetric or asymmetric in construction.

Films of the invention can utilize different materials for the outer layers or for the intermediate layers, so that e.g. two "A", "B", or "C" layers can be different from each other in composition, degree of crosslinking, thickness, or other parameters.

It can be seen that improvements in several film parameters are beneficially obtained by the present invention. For films with equal levels of irradiation, films of the invention exhibited improved flowability, as measured by film melt flow index (MFI). For example, in Table 2, C.1 has an MFI of 2.8, compared with an MFI of between 2.9 and 4.8 for Exs. 1 to 5; in Table 3, C.2 has an MFI of 1.7, compared with an MFI of between 2.1 and 4.2 for Exs. 7 to 10. In Table 6, C.5 has an MFI of 2.7, compared with an MFI of 4.1 (Ex.25) and 4.5 (Ex.24). Table 8 also shows a peak force of 1.9 for C.5, compared with a peak force of between 2.0 and 2.5 for Examples 24 to 26a. These melt flow index and peak force values result in better package performance by reducing the % leakers in packages made at relatively high speeds (70 ppm). For example, C.1 of Table 3 resulted in 17% leakers at 70 ppm, whereas Ex. 9 had only 3% leakers at the same packaging speed. In Table 7, C. 6 resulted in 78% leakers at 70 ppm, whereas Ex. 27 had only 15% leakers at the same packaging speed.

Films of the invention also showed improved optics, with Table 6 showing control film 5 with a clarity of 75%, and a haze of 6.7%. Examples 24 to 26a showed either equivalent optical clarity (Example 25) or improved clarity (76 to 82% in Examples 24 and 25a to 26a). Except for Example 25, Examples 24 to 26a showed lower (i.e. improved) haze values.

Compared with C.7, Example 28 showed lower leakers (0% versus 7%), improved abuse resistance (4% cuts versus 11% cuts), and higher hot tack peak force (5.8 versus 4.3 N).

## 55 Claims

1. A film comprising at least one layer comprising a blend of

5 a) a first polymer having a crystalline melting point of at least 127°C (260°F) and a density of at least 0.925 g/ml, and  
b) a second polymer comprising an ethylene/alphaolefin copolymer with a density of less than 0.916 g/ml; wherein the film heat seals at a temperature of at least 82°C (180°F).

10 2. The film of claim 1 wherein the film is crosslinked.  
3. The film of claim 1 or claim 2 wherein the film has a thickness of between 10 to 50 $\mu$ m (0.4 and 2.0 mils).  
4. The film of claim 1 wherein the film has a hot tack strength of at least 2N for a 25 mm (1 inch) wide sample.  
5. The film of any preceding claim wherein the first polymer is selected from the group consisting of ethylene polymer having a density of at least 0.925 g/ml polypropylene, and propylene/ethylene, preferably selected from the group consisting of linear medium density polyethylene and high density polyethylene copolymer.  
15 6. The film of any preceding claim wherein the second polymer is selected from the group consisting of very low density polyethylene and single-site catalyzed ethylene/alpha olefin copolymer.  
7. The film of any preceding claim in which the said at least one layer comprises a third polymer selected from the group consisting of ethylene polymer having a density of between 0.916 and 0.924 g/ml preferably linear low density polyethylene or ethylene/unsaturated ester copolymer, preferably ethylene/vinyl acetate copolymer or ethylene/alkyl acrylate copolymer.  
20 8. The film of any preceding claim which is oriented.  
9. The film of claim 8 wherein the film is heat shrinkable.  
10. A film according to any preceding claim which is a multilayer film comprising  
30 a) a core layer comprising an oxygen barrier; and  
b) two outer layers each comprising the said blend.  
11. The film of claim 10 wherein the oxygen barrier is selected from the group consisting of ethylene/vinyl alcohol copolymer, vinylidene chloride copolymer, polyester, and polyamide.  
35 12. The film of claim 10 or claim 11 further comprising an intermediate layer disposed between the core layer and at least one of the outer layers, and comprising a polyamide.  
13. The film of any of claims 10 to 12 further comprising an adhesive layer disposed between an intermediate layer and an outer layer.  
40 14. A process of packaging in which a film according to any preceding claim is heat sealed at a temperature of at least 82°C to close a package and seal the contents therein.  
15. A process according to claim 14 in which the film is sealed across the walls of a tray.  
45 16. A process according to claim 14 or claim 15 in which film on the heat sealed packages is heated to cause it to shrink.

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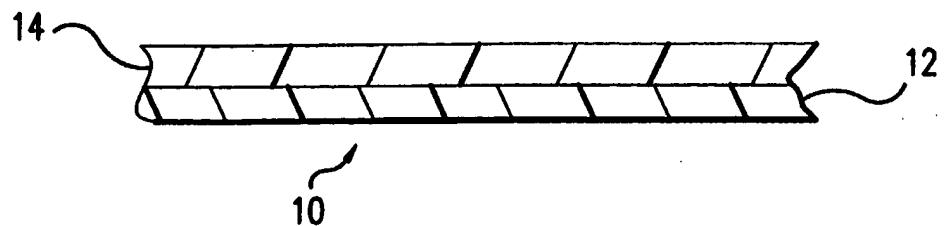


FIG.1

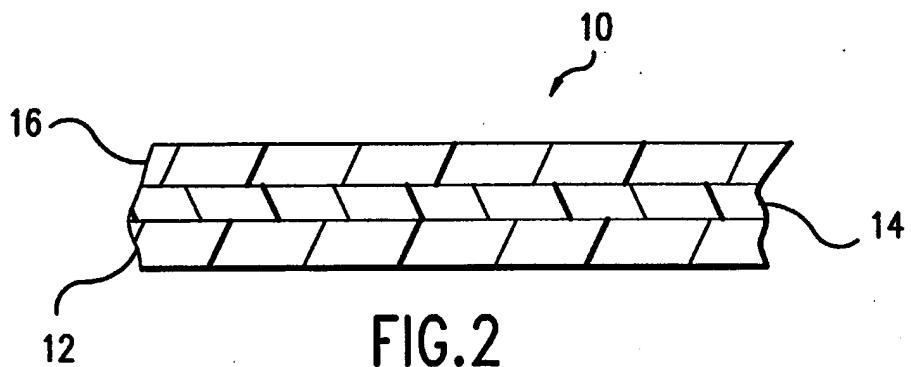


FIG.2

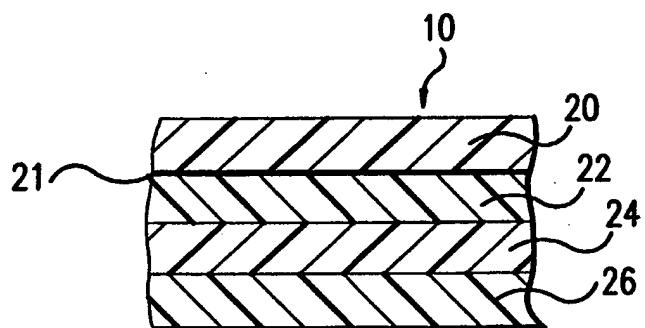


FIG.3

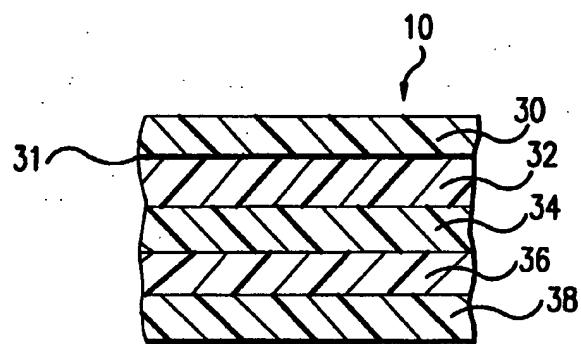


FIG.4

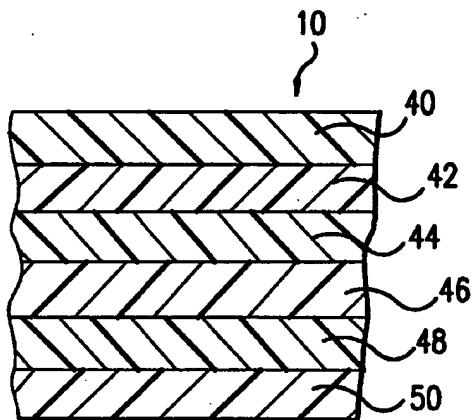


FIG.5

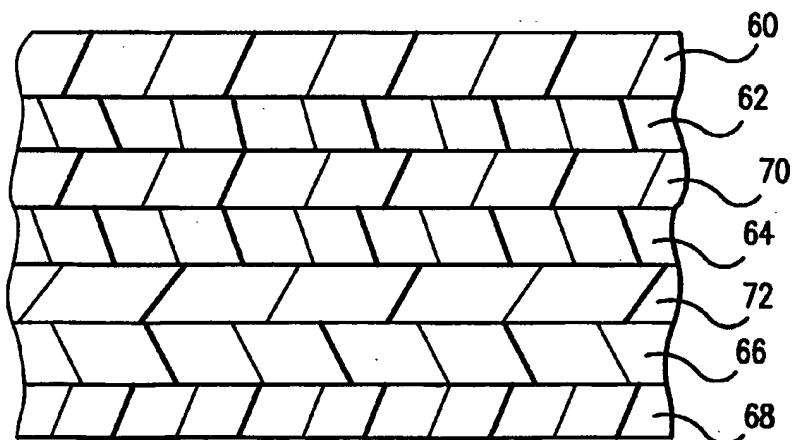


FIG.6

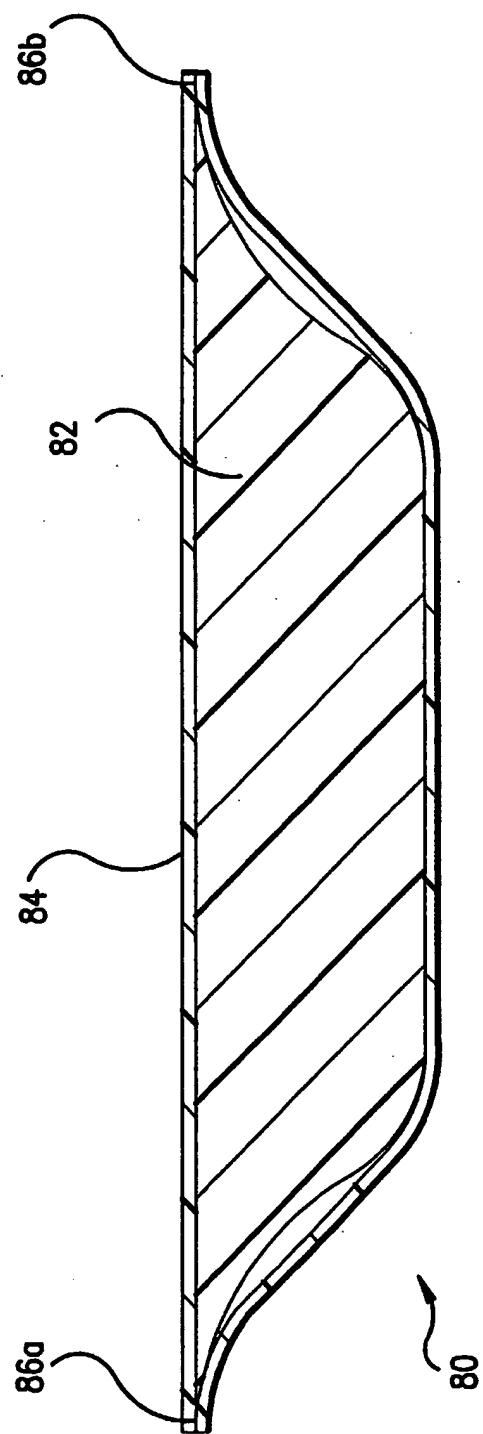


FIG. 7



European Patent  
Office

## EUROPEAN SEARCH REPORT

Application Number  
EP 97 30 2480

## DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	WO 94 07954 A (DU PONT) 14 April 1994 * claims 1-17 * * page 10, line 7 - line 11 * * page 12, line 21 - line 25 * * page 15, line 24 - line 30 * * page 16, line 18 - line 31 * ---	1-16	C08J5/18 B32B27/08 B65D65/40 //C08L23:08
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A	EP 0 597 502 A (GRACE W R & CO) 18 May 1994 * claims 1-27 * ---	1-16	
A	GB 1 591 423 A (GRACE W R & CO) 24 June 1981 * page 1, column 2, line 63 - line 91 * ---	1-3, 8-11,16	
TECHNICAL FIELDS SEARCHED (Int.Cl.6)			
C08J C08L B32B B65D			
The present search report has been drawn up for all claims			
Place of search  THE HAGUE	Date of completion of the search  8 August 1997	Examiner  Richards, M	
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application I : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			